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Original Article

EXPERIMENTAL AND FINITE ELEMENT ANALYSIS ON THE MECHANICAL PERFORMANCE OF HYBRID FIBER REINFORCED EPOXY COMPOSITES

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ABSTRACT

Fiber reinforced composites are the new age materials, which play a major role in the service sector and engineering field. These materials are tailor-made materials with a different volume fraction of resin and fibers, and the stacking sequence could be made unique for each application depends on the strength requirement. Therefore, whenever engineers try to use a new configuration the proposed laminate has to be tested for its mechanical performance. Nevertheless, experimental testing of each new laminates is a time consuming and expensive process. In this work, comparative study on the results of the mechanical performance of glass/kenaf and glass/aloe Vera fiber reinforced epoxy composite laminates obtained using both experimental testing and Finite element Analysis Method (ANSYS 16.2) is done to find the closeness between the results from the two methods. The laminates are prepared using vacuum assisted resin transfer molding method (VARTM), and the tensile and flexural tests are carried out based on ASTM standard. The comparison of the experimental and FEA method shows that the variation in results is only between 8 to 3%, in two types of laminates, proving that the Finite element method is equally effective, less time consuming and economical for composite analysis.

KEYWORDS: Hybrid Fiber Reinforced Laminates, Mechanical Properties, Experimental, FEA Method & VARTM

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Nomenclature

GAG - Glass /Aloe Vera/ Glass fiber reinforced Hybrid Laminate

GKA - Glass/ Kenaf/ Glass fiber reinforced Hybrid Laminate

KGA – Kenaf/ Glass/ Aloe Vera fiber reinforced Hybrid Laminate

VARTM- Vacuum assisted resin transfer molding method

INTRODUCTION

In today’s scenario, attention has turned towards biodegradable materials in structural application [1]. Natural fiber reinforced. composite is a better option, with respect to that, many types of research are on going in this field. M. Ramesh, K. Palanikumar, K. Hemachandra Reddy [9] found out that sisal /Glass fiber composite is performing well with the tensile load Maries Idicula Kuruvilla Joseph, Sabu Thomas [3] found that banana/sisal hybrid fiber reinforced polyester composites results in a positive hybrid effect in tensile and flexural properties Meenakshi C. M, Krishnamoorthy A [4] hybrid fiber composites can be used as an alternate for glass fiber

composites depend on the strength required, by which, the synthetic content in polymeric matrix composites can be reduced Ramesh et al [5] found that jute/glass fiber composite is having the good tensile strength and jute/sisal/glass fiber is having good flexural strength.

As these composites are tailor-made material in nature depending on the application, whenever engineers try to use a new configuration, the proposed laminate has to be experimentally tested for its mechanical performance, which is a time to consume and expensive process, therefore, the new trend in research is using numerical method for analysis of composites. M Gutu [6] is saying that currently the best method of numerical analysis is the finite element method (FEM). Vishnu Prasad et al [7] has compared the experimental and finite element results of Tensile test results, and proved the results to be closer. Also natural fiber's application has been proven in components like gears by C. M. Meenakshi [8]

In this work, two types of hybrid fiber reinforced laminates are prepared with Glass/kenaf and Glass /Aloe vera by using VARTM method, and their tensile and flexural strengths are computed experimentally, and compared using Finite element Analysis (ANSYS 16.2).

EXPERIMENTATION

Materials and Manufacturing

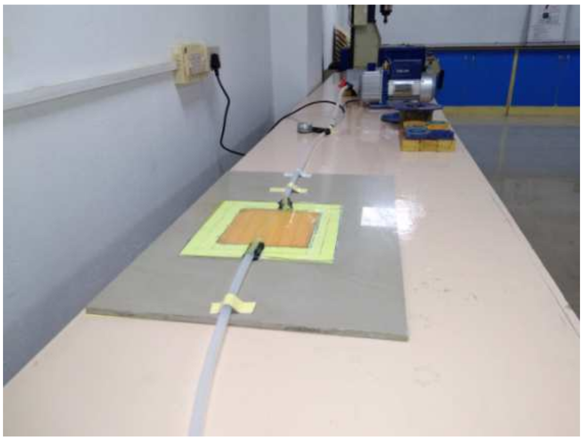

Figure 1: Vacuum Assisted Resin Transfer Molding Setup

The hybrid composites are fabricated with glass, kenaf and aloe vera biaxial woven mat (0 and 90 degrees) of size 300 x 300 mm. To achieve laminates of 3mm thickness, the mates are arranged as glass/kenaf/glass, glass/aloevera/glass and aloevera/glass/kenaf for the first, second and third type of laminates, the mats are stitched together to form a perform and the laminates are made using Vacuum Assisted Resin Transfer Moulding (VARTM) setup [9] epoxy resin and hardener HY951 mixed in 10:1 ratio. VARTM is a single-sided molding process that uses vacuum pressure to bring resin inside to perform, which is sealed under a flexible vacuum bag. Three types of laminates in three different schemes are prepared as shown in Figure: 2

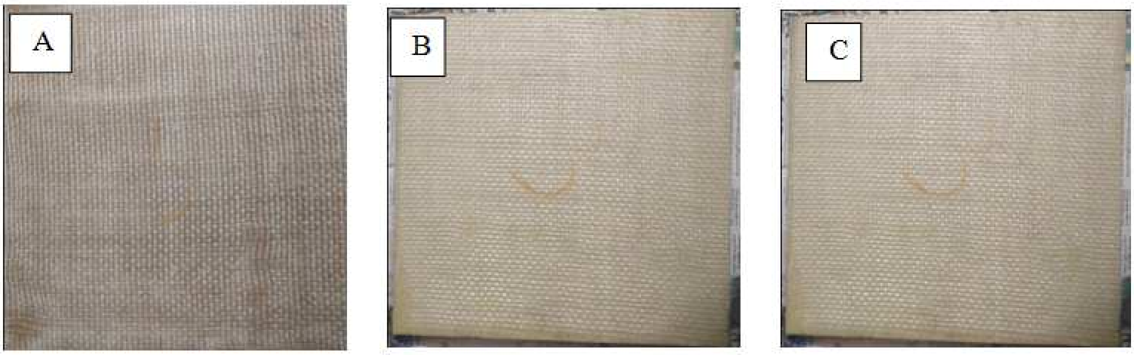

Figure 2: Laminates (a) GAG Laminate (b) GKG Laminate (c) KGA Lamina

Experimental Testing

Samples are cut according to ASTM standards D-638. The tensile test was done on UTM with maximum capacity 600 KN at room temperature, results show that the GKG, Kenaf /glass fiber reinforced laminate is having good tensile strength compare to GAG and the tensile strength reduced much when more hybridization is done i. e. when natural fiber proportion increased the strength decreases

Figure 3 (a): Tensile Test Samples (b): Flexural Test Samples

Samples are cut according to ASTM D-790. The flexural test was carried out in a UTM. The flexural test result shows that all the types of laminates have good strength value of more than 100 N/mm^2. Among that, GKG is having the higher flexural strength of 348.24 N/mm$^{2\ due}$ to the flexural nature of the Kenaf fiber. The tensile and flexural test results given in Table 1 are average of five samples tested. Tested samples are shown in figure 3.

Table 1: Experimental Test Result of Tensile and Flexural Strength from ANSYS

Sno	Composite Type	Tensile Strength N/Mm2	Flexural Strength N/Mm2
1.	GKG	91.4	348.24
2.	GAG	67.5	258.67
3.	KGA	38.3	109.86

FINITE ELEMENT ANALYSIS

Finite element Analysis is an advancement of engineering analysis, which will give an accurate result. In this work, the experimental results obtained are compared with the FEA results to find out the percentage of deviation between the two; if the deviation is less instead of doing experimental study all the time, the researchers can opt for FEA study which is less time consuming and economical. Already researchers have started using the FEA method for validating their composite material experimental result [6, 7]. For analyzing the composite specimen model, engineering data and materials properties are mandated. The properties used are given Table: 2 For finite element analysis purpose, the material is

considered as isotropic all the properties like density, modulus and poison's ratio are calculated using composite mechanics, the rule of mixture formulas and the boundary condition and load conditions are followed as in experimentation.

Table 2: Input Table for ANSYS

S. No.	Sample	Density, ρ (gm/cm3)	Young's E_L	Young's E_T	Poisson's Ratio, ?	Force F (kN)	Force P (kN)
1.	GKG	1.36	20.8	4.871	0.1849	3.55	0.159
2.	GAG	1.69	17.5	4.606	0.1672	2.66	0.124
3.	KGA	1.50	14.3	4.583	0.1836	2.02	0.056

Tensile Test (ASTM D-638) and Flexural Test (ASTM D-790) are carried out on ASTM standard size designed samples. The sample analyzed the result of tensile and flexural deformation and stress of the composite materials are given in Figure: 4 and Figure: 5 all the results obtained are with the same loading and boundary condition as in case of experimentation work. The values of tensile and flexural strength are shown in Table: 3

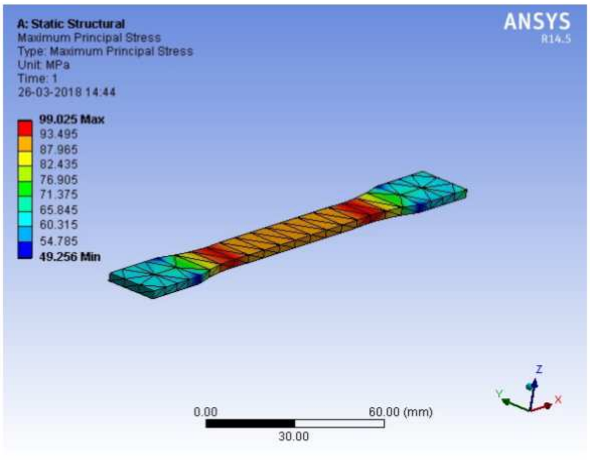

Figure 4: Tensile Stress in GKG Sample

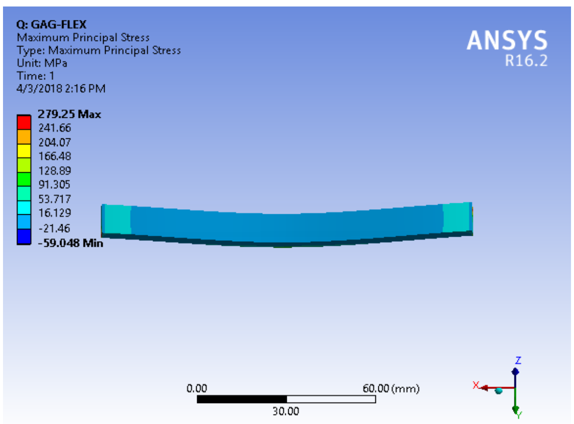

Figure 5: Flexural Stress in GAG Sample

Table 3: Finite Element Analysis Test Result

S.NO	Composite type	Tensile Displacement mm	Tensile strength N/mm2	Flexural Displacement mm	Flexural strength N/mm2
1.	GKG	3.98	99.025	21.38	359.97
2.	GAG	3.56	74.248	17.63	279.25
3.	KGA	3.30	56.220	8.04	127.32

COMPARISON OF RESULTS

The experimental and the simulation results obtained using ANSYS software are compared. The Comparisons of tensile strength values are as shown in Figure 6 and Figure: 7 show the comparison of flexural strength values Results revealed that numerical results are better than experimental results. These deviations in the results may be due to manufacturing defects of composites like voids and human influence on testing procedure etc However, the deviation is less in percentage. The overall comparison shows that the order of performance among the three composites is same as GKG, GAG, and KGA in both the method of analysis.

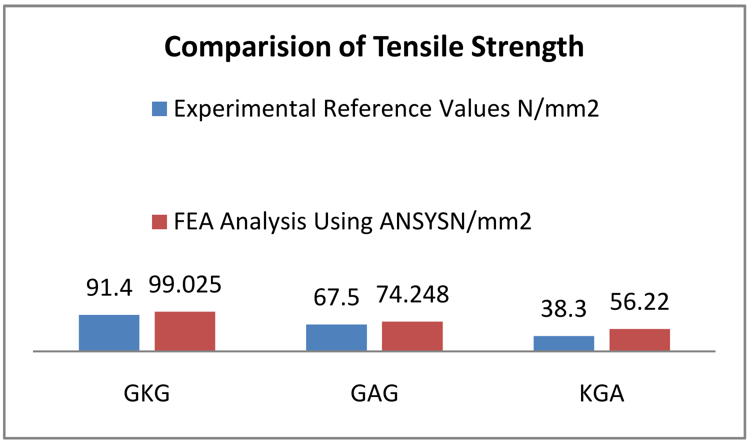

Figure 6: Comparison of Experimental and ANSYS Tensile Strength Result

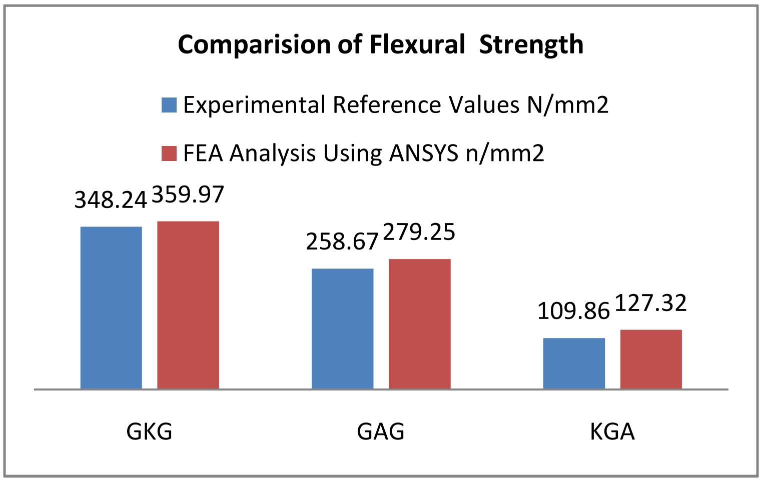

Figure 7: Comparison of Experimental and ANSYS Flexural strength Result

CONCLUSIONS

The following conclusions are made from this research work.

- The comparison between two methods of the study shows that there is a variation of 8% to 3% in the GKG and GAG and little higher in KGA laminate results.
- Irrespective of the variation, the order achieved in both the methods is the same i. e the performance rankings among the three laminates are the same in both methods.
- Glass/Kenaf fiber reinforced hybrid composites are showing good performance in tensile and flexural Behaviour.
- Numerical results are better than the experimental results; therefore, future researchers can very much depend on FEA methods for composite analysis.

Further, this research could be extended by doing more analysis like impact and fatigue, and also can be extended over different combinations of materials.

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